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BISTABLE MEMBRANE VALVE

The technical scope of the present invention is that of valves and more particularly the use of these valves in inflation and deflation valves for the tire of a motor vehicle wheel.

The principle of valves allowing the remote inflation and deflation of vehicle tires is known by patents FR-87.07772, FR-90.12858 and FR-95.03299.

The technique implemented when using these inflating and deflating valves is that of single valves able to let pressurized air through to the tire when in one position, and when in another to allow air contained in the tire to escape to the exterior, and when in a resting position to isolate the tire by closing off the air flow circuit.

To achieve this, a membrane is used that is subjected to a spring and coupled with a single valve formed of a chamber and closing means. The closing means currently employed are that of a ball. This system has proved its efficiency in heavy vehicles.

The drawback to this system lies in the fact that, applied to light vehicles, the internal pressure of the tire is much lower than that of heavy vehicle tires whereas the wheel spin rate is much greater. These different factors cause the inflating valve to malfunction, essentially because of the centrifugal forces applied to the ball or to the vertical accelerations to which the vehicle's wheels may be subjected.

The aim of the present invention is thus to overcome this problem by proposing a single valve that fulfils the same role in inflation/deflation valves but whose production costs are reduced and whose constituents will remain unaffected by those forces likely to generate malfunctions.

The present invention thus proposes the replacement of the single valve constituted by a seat, a steel ball and a barrier grid for the ball, by a single valve constituted by a seat and a membrane having two stable positions.

The invention thus relates to a single valve to close an inflation circuit and composed of a seat and an openwork semi-rigid membrane able to adopt two stable positions.

According to one characteristic, one of the stable positions prevents the circulation of fluid whereas the other stable position allows the circulation of fluid.

According to another characteristic, the single valve is activated by a difference in pressure upstream and downstream of the single valve.

According to another characteristic, the membrane is made of a polymer (for example, rubber or latex).

According to yet another characteristic, the membrane is made by stamping a metal sheet.

According to another characteristic, the membrane is made by duplicate molding an elastomer onto a metallic core grid.

Advantageously, this single valve is insensitive to the centrifugal forces resulting from the high spin rate of the wheel.

Advantageously again, the use of this single valve allowing the number of elements in the inflation valve to be reduced, thereby reducing production costs and simplifying manufacture.

Another advantage lies in the fact that this single valve, in addition to the initial functions of the inflation valve, enables the gradual deflation of the tire.

Other characteristics, particulars and advantages of the invention will become more apparent from the description given hereafter by way of illustration and in reference to the drawings, in which:

- Figure 1a shows a top view of the bistable membrane,
- Figure 1b shows a section, along plane AA', of the bistable membrane in its first stable condition,
- Figure 1c shows a section, along plane AA', of the bistable membrane in its second condition,
- Figure 1d shows a section, along plane AA', of a bistable membrane incorporating a core grid,
- Figure 2a shows a section of the bistable membrane valve in its first stable condition,

- Figure 2b shows a section of the bistable membrane valve in its second stable condition,
- Figures 3a to 3c are sections, at a different scale, of an inflation/deflation valve illustrating the use of the invention.

The single valve proposed by the invention is thus composed of a seat and an openwork bistable membrane. This single valve is intended to be inserted into an inflation and deflation valve such as is described in patent FR-95.03299.

Figure 3a shows an inflation and deflation valve 10, formed of a single valve 1, a spring 12, a valve membrane 11, a base 14 and a cap 16. The valve 10 is connected to a tire, not shown in the Figure, by means of the bore in the base 14. Via the bore made in the cap 16, the chamber 8 of the valve 10 is connected to a pressurising/depressurising system not shown in this Figure. The chamber 15 delimited by the valve membrane 11 and the base 14 communicate with the exterior by means of slots 13. The single valve 1 used is, according to the invention, constituted by a seat 6 and a bistable membrane 2.

Since the functioning of the inflating/deflating valve and the pressurizing system are already described in the aforementioned patent, reference may easily be made to this document for a more detailed explanation.

Figures 1a to 1d respectively show a top view of a bistable membrane and a section view along plane AA' in both its stable positions. This membrane is a body of revolution constituted by a cylindrical wall and an openwork bottom with openings 3. The body may be of a semi-rigid material, for example a polymer, a stamped metal sheet, or else a polymer molded over core grids 4 and 5. Another embodiment of said membrane may be envisaged if this embodiment enables the membrane 2 to have two stable positions. Figures 1a to 1c show a semi-rigid polymer membrane and Figure 1d shows a membrane with core grid. These core grids 4 and 5 may for example be made of metal or plastic. To make the membrane 2 move from the first stable condition (Figure 1b) to the second stable condition (Figure 1c), a force F must be

applied oriented inwards and greater than or equal to the minimal transition force F_1. This force F_1 depends on the constitutive material or materials, the shape of the membrane and the temperature. Under the effect of this force F, the central part of the membrane 2 is displaced towards the inside of said membrane, thus moving from a high position to a low position. Conversely, to move the membrane 2 from the second stable condition into the first stable condition, a force F′, oriented outwards and greater than or equal to the minimal transition force F_2 must be applied.

Figures 2a and 2b show the single valve 1, composed of the bistable membrane 2 and its seat 6. The seat is of revolution and incorporates at its centre an opening 9 of a diameter d. When the membrane is in its first stable conditions shown in Figure 2, the central part of the membrane presses on the periphery of the opening 9 thereby ensuring the total isolation of the chamber 7 inside the single valve and the enclosed space 8 located above the single valve. Openings 3 are positioned such that, in this first stable condition of the membrane, they do not allow fluid to circulate between the chamber 7 and enclosed space 8. To move from the first stable condition into the second, a force F greater than F_1 must be applied to the upper part of the membrane. This force is made here by the difference in pressure between the chamber 7 and the enclosed space 8. The minimal pressure enabling a change in condition is:

$$\mathbf{P_8 \geq P_7 + 4 * F_1/\Pi d^2}$$

Where P_7 is the pressure in the chamber 7 and P_8 the pressure in the enclosed space 8.

Conversely, the passage of the membrane from the second stable condition into the first is made by the flow of a fluid through the openings 3, which creates a difference in pressure between the chamber 7 and the enclosed space 8. The maximal condition transition pressure is thus:

$$\mathbf{P_8 \leq P_7 - F_2/S}$$

where S is the contact surface of the upper part of the membrane, subjected to the difference in pressure between the chamber 7 and the enclosed space 8.

If we consider that the openings 3 have a total area s, and that the membrane 2 has an inner diameter D, the value of S may easily be calculated:

$$S = \Pi D^2/4 - s$$

The openings 3 will thus be dimensioned according to the technical characteristics of the membrane and the difference in pressure required to be obtained during the flow of fluid.

Figures 3a to 3c show the integration of the single valve 1 according to the invention into an inflation and deflation valve. Figure 3a shows the inflation valve in its resting position, with the pressure in chamber 7 being identical to the tire pressure and the pressure in the enclosed space 8 substantially equal to the atmospheric pressure. A spring 12 holds the valve membrane 11 against its base 14 and the bistable membrane 2 is in its stable position blocking the single valve. The inflation valve is thus fully sealed. The inflation valve fitted with the single valve 1 according to the invention has a very simple technical structure where the single valve 1 has just two elements to ensure the opening and closing of the inflation valve. Such a single valve namely improves the reliability and stability of the inflation valve.

Figure 3b shows the deflation of the tire where, as described in patent FR 95-03299, the enclosed space 8 is depressurized so that the pressures in chambers 7 and 15 are sufficiently greater than that in the enclosed space 8 for the spring 12 to be compressed. The valve membrane 11 moves away from its seat 14 and the air contained in the tire is able to escape via openings 13. The difference in pressure of chambers 7 and 15 with respect to enclosed space 8 keeps the bistable membrane 2 in the position in which it blocks the single valve.

Figure 3c shows the single valve 1 in is second stable position described above. This position enables two different operations to be performed. When the tire is being inflated, great enough pressure ($P_8 \geq P_7 + 4* F_1/\Pi d^2$) is applied in the enclosed space 8 to trigger the single valve's change of position. The fluid is thus able to flow through openings 3,

the pressure in the enclosed space 8 being greater than that in the chamber 7 and the fluid flowing from the enclosed space 8 to the tire.

When the single valve 1 is in this second position, slow deflation may be performed. By progressively reducing the pressure in the enclosed space 8 so as to constantly keep it slightly under that of the chamber 7, the difference in pressure is not enough for the membrane 2 to change its position and the fluid contained in the tire escapes into the pressurization/depressurization system. In this configuration, the fluid moves from the chamber 7 to the enclosed space 8 and thus performs the slow deflation of the tire. To carry out this slow deflation, the pressure P_8 of the enclosed space 8, must be adjusted to as to obtain:

$$P_7 \geq P_8 \geq P_7 - F_2/S$$

where P_7 is the pressure in the tire and thus in the chamber 7.

It is also possible for the pressure in the tire to be measured when the single valve is in this second stable position. By stabilizing P_8 such that the flow of fluid through the single valve 1 is nil, P_8 and P_7 are identical, the single valve remains open and the pressure in the tire may be measured using a pressure sensor in the pressure regulation system.

To return to the first stable position of the single valve, the pressure merely has to be made to drop (for example by opening the supply circuit to the enclosed space 8 towards the exterior) so as to obtain the following relation:

$$P_8 < P_7 - F_2/S$$

The single valve closes and is sealed once again.